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ABSTRACT

The focus of the presentation pertains to the informational consequences of knowledge of results. Knowledge of results is assumed to be corrective in that the learner is informed that a previous response(s) was wrong. Provided the learner has an opportunity to rehearse or practice following feedback, the feedback procedure or session is in a sense a study trial. Consequently, subject variables (individual differences) and task variables would be expected to interact with mode and type of feedback. An emphasis on the interaction of informative feedback with task and subject variables would appear to be a fruitful avenue for future research in productive learning. It is believed that such an approach would prove to be successful provided there is a consideration of the errors following feedback as well as correct performance. A model of multiple-choice processing is developed in order to provide a context for the consideration of the role of informative feedback. A consideration of the analysis of errors and their usefulness in the understanding of the processing of feedback is provided. (Author/MV)

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The Role of Informative Feedback in Productive Learning

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ABSTRACT

As the term informative feedback would denote, the focus of the presentation pertains to the informational consequences of knowledge of results. Knowledge of results is assumed to be corrective in that the learner is informed that a previous response(s) was wrong. Provided the learner has an opportunity to rehearse or practice following feedback, the feedback procedure or session is in a sense a study trial. Consequently, subject variables (individual differences) and task variables would be expected to interact with mode and type of feedback. An emphasis on the interaction of informative feedback with task and subject variables would appear to be a fruitful avenue for future research in productive learning. The author believes that such an approach would prove to be successful provided there is a consideration of the errors following feedback as well as correct performance. A model of multiple-choice processing is developed in order to provide a context for the consideration of the role of informative feedback. A consideration of the analysis of errors and their usefulness in the understanding of the processing of feedback is provided.

The Role of Informative Feedback in Productive Learning

Gary D. Phye

Since the early work of E. L. Thorndike, it has been assumed that informative feedback in the form of knowledge of results facilitates performance. Whether the improvement in performance is the result of motivational or informational consequences depends in part on the type of task under consideration. When the task is verbal and meets the definition of productive learning here under consideration, the informational consequences appear to predominate. For example, the importance of the informational consequences of knowledge of results in programmed instruction has been considered by Anderson (1967). Also, the role of feedback has been considered within the context of classroom tests. Kulhavy & Anderson (1972), Phye & Baller (1970), and Sassenrath (1975) have marshalled evidence for the role of informative feedback in the facilitation of classroom learning through the correction of previous errors.

In this paper, productive learning is considered to be semantic in nature. The earlier references to the effect of

informative feedback when learning involved classroom materials is a reflection of the unit of analysis under consideration. More specifically, semantic memory (Tulving, 1972) is the organized knowledge a person possesses about words, meanings, relations, concepts, rules, etc. Inputs into semantic memory are processed and related to existing cognitive structures. Further, since this paper is not concerned with the use of mnemonic devices or strategies in order to enhance classroom learning, productive learning is considered to be nonstrategic-semantic (Brown, 1975) in nature. Here, the type of task is defined as meaningful and consequently deliberate mnemonic strategies are not required for either the reproduction of general semantic content or in some cases exact reproduction.

Having defined the type of task and type of learning to be considered, a brief consideration of the role of informative feedback is necessary. In keeping with the semantic nature of the present conceptualization of productive learning, informative feedback is defined in terms of its semantic content. Thus, feedback could take the form of words, rules, concepts, meanings, etc.

The role of feedback is either to provide confirmation of existing knowledge structures and schemes or to provide a semantic basis for the modification of an existing structure or scheme that is wrong.

Having characterized productive learning and informative feedback, the remainder of the paper will be directed toward the development and consideration of theoretical and methodological factors. Additionally, a model for multiple-choice (M-C) performance from an information processing perspective is introduced. The M-C model is introduced in order to provide a context for a consideration of errors following informative feedback. The error analysis that is proposed will provide a basis for identifying breakdowns in the processing of informative feedback. Finally, data are presented that demonstrates the utility of the proposed theoretical methodological approaches in trying to understand the role of informative feedback in productive (classroom) learning.

Theoretical Considerations:

As a result of an increased emphasis upon the informational consequences of feedback and the increasing number of studies

that indicate that traditional operant conditioning principles do not appear to apply, behavioral theory of the Skinnerian ilk is being questioned as an adequate explanation for the effects of informative feedback in productive learning. A case in point is the phenomenon referred to as the delayed-retention effect (DRE). The DRE is a phenomenon where groups that have feedback delayed for some period recall significantly more than groups who receive feedback immediately following learning (More, 1969; Sassenrath & Yonge, 1968, 1969; Sturges, 1969, 1972; Kulhavy & Anderson, 1972; Suber & Anderson, 1975; Sassenrath, 1975). These data, of course, violate the principle of immediate reinforcement.

While the aforementioned shortcoming of behavioral theory to explain an effect of feedback in productive learning might lead one to conclude that behaviorism has little to offer, caution is warranted. As has been pointed out by Farnham-Diggory (1972), behaviorism may be considered as method as well as theory (pp. 77-78). While behavioral theory may be inadequate in explaining the cognitive processing involved in productive learning, behavioral methodology as a method of objectivity in the experimental sense is common to

all psychological theories, including cognitive theories. Given, that methodological objectivity in the experimental sense is necessary for the testing of a proposed learning model, attention can then be focused on theoretical characteristics of cognitive theories.

In light of the recent emphasis upon the investigation of cognitive processes involved in instructional situations (Klahr, 1976), and an increased utilization of information processing theory, an examination of theoretical assumptions provided by Carroll (1976) is essential reading for those persons who in the future will be examining the role of informative feedback in instruction. For example, the recent shift in emphasis from the motivational to the informational consequences of feedback in studies of productive learning (Kulhavy & Anderson, 1972; Suber & Anderson, 1975; Sassenrath, 1975; Phye, Gugliemella & Sola, 1976; Kulhavy, Yekovich & Dyer, 1976) attests to an increased awareness of cognitive and informational processing theories. However, a careful reading of these studies suggests the cautious theorizing of persons caught in a paradigm shift (Kuhn, 1962). A common theoretical stance seems to be that of one foot in the behavioral

camp and the other in the cognitive camp. While the aforementioned stance may be comfortable, there are potential dangers. According to Reese and Overton (1970), this type of synthesis or eclecticism leads to confusion because it mixes metaphysical assumptions. However, the translation of a theory from one model to another is not the same as synthesis or assimilation. "Translation involves taking the terms and propositions from one theory (and from its model), redefining them consistently with the new model, and relating them to other terms in the new theory. Translation, in other words, is actually the construction of a brand new theory with an unmixed model" (Reese & Overton, 1970; pp. 121). Consequently, the delineation of assumptions provided by Carroll (1976) should alleviate this problem for future research efforts in the area of feedback and productive learning. With the admonition of Reese and Overton (1970) in mind, we turn now to a consideration of theoretical assumptions delineated by Carroll.

Cognitive Considerations:

The present author is in almost total agreement with Carroll's (1976, pp. 16) definition of cognitive theory. "By 'cognitive theory' I mean a theory that would embrace covert acts

such as expectancies, plans, sets, images, memory storage and retrieval, conscious control and complex information processing. I assume that contemporary experimental technology (as represented for example by reaction time studies, computer simulation of behavior, etc.) has meaning for elevating these concepts to scientific respectability".

In addition to defining cognitive theory, Carroll (1976) has analyzed the basic theoretical assumptions of behavioral theory of the operant conditioning variety and cognitive learning theory. Rather than enumerate all of the assumptions offered by Carroll, only those cognitive assumptions pertaining directly to the role of feedback will be considered. The following assumptions are felt by Carroll to be central to a theory of learning that considers feedback as an integral part of the learning process.

1. Cognitive theory would, for the most part, agree with naive theory in asserting that information is what is learned, and would object to behavior theory's postulation that it is the responses that are learned. According to cognitive theory, learning to make particular responses is an internal process, as is also a decision to emit

them on a particular occasion and under particular conditions. . . . .

2. Feedback and correction, in cognitive theory, would be regarded as merely one kind of information contributing to learning - though frequently an important kind of information.

3. Reward and reinforcers (including aversive stimuli and their withdrawal) would merely constitute another kind of information utilized in producing learning, but rewards would be neither universally necessary nor sufficient. Their relevance is minimal, for example, in observational and incidental learning (Carroll, 1976; pp. 17).

Methodological Considerations:

Inasmuch as most of what has been learned from instruction at the upper educational levels is measured with a multiple-choice (M-C) test, this paper will consider the processing of information within the context of M-C behavior following informative feedback.

The multiple-choice format is frequently used to assess productive learning as is witnessed by its extensive use on standardized achievement and aptitude tests. In the experimental

literature, the M-C format has been used to measure the comprehension and retention of classroom materials (Phye & Baller, 1970; Sassenrath and Garverick, 1965; Suber & Anderson, 1975) following informative feedback. Also, Anderson (1972) has recommended the use of a multiple choice format in conjunction with paraphrasing in order to measure comprehension. These studies have been cited in order to indicate the ubiquitous use of the M-C format in assessing learning that would meet almost anyone's definition of productive learning.

Within the context of informative feedback, knowledge of results is assumed to be corrective in the sense that a learner is informed when a previous response(s) is wrong. Provided the learner has the opportunity to rehearse during or following feedback, the feedback is in a sense an additional study trial. Consequently, consideration must be given to the processing of feedback as well as the processing of a stem and alternatives that constitute an item on a M-C test. Recent considerations of human memory have stressed the importance of different types of processing in recognition memory (Anderson & Bower, 1973). These proposed different types of processing would suggest a reconsideration of M-C

performance. For example, in the context of Human Associative Memory (HAM), Anderson & Bower consider the recognition of classes, individuals, and familiar patterns (perceptual concepts) with or without retrieval of context. This conceptualization of the recognition process certainly differs from previous definitions of the recognition process as not involving a retrieval process or the use of retrieval cues (Kintsch, 1970).

A few words concerning the measurement of complex information processing variables is deemed necessary. As I have pointed out elsewhere (Phye & Gugliemella, 1977), the assumption should be made that M-C test performance is multivariately determined. In this instance, the term multivariate is used in both of two senses. In the first sense, correct performance with a M-C format is undoubtedly due to a number of factors of which more than one can be incorporated into the experimental design as independent variables. In the second sense, the proposed error analysis requires a consideration of more than one dependent variable per subject. Also, the measurement of the processing of informative feedback in M-C testing is in essence the measurement of change. An attempt is made experimentally to specify the processes involved in the change or accommodation of knowledge structure. Consequently, a minimum of two

measurements at different points in time is required. Ideally, the same subject is tested on both occasions so that each person serves as his/her own control. A statistical corollary would be the use of either a within subject or a split-plot with repeated measures design.

Multiple-Choice Test Performance

In order to examine the role of informative feedback in productive learning when learning is assessed using a M-C format, a consideration of the processing involved in M-C test performance is required. The following is a proposed model that attempts to account for the processing involved in M-C performance. While aspects of the model follow from data out of our lab. (Phye, Gugliemella & Sola, 1976; Phye & Gugliemella, 1977), several aspects are untested empirically and are presented here because of their heuristic potential. This model incorporates an information processing perspective and considers that instances of both storage and retrieval from memory are included in an explanation of M-C performance.

As depicted in the flow chart shown in figure 1, the proposed model consists of several stages and involves more than a simple discrimination process.

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A major reason for the inability to account for M-C performance without considering a retrieval process is the fact that the stem of a test item may serve to direct attention or serve as a retrieval cue for semantic context. For example, when encountering a multiple-choice test item, a subject will typically read the stem followed by a reading of the alternatives. Recognition without retrieval of context may occur if the stem furnishes grammatical or syntactical cues that can be used in selecting an alternative. If this situation occurs, the subject goes to the next item. If not, the subject will go back to the stem and try to use it to establish a context for memory search. In addition to the use of the stem as a retrieval cue in order to establish context, the stem may also serve as a cue for the retrieval of classes of information within a context. For example, if the stem dealt with classroom management and the promotion of consistent responding, the context would be operant conditioning principles and the class would be schedules of reinforcement. It is assumed that the retrieval of context is a necessary but not sufficient condition for class retrieval. If the stem has not served as a cue for the retrieval of context, the subject will probably guess at

this point and go to the next item. If the stem can be used to retrieve not only context but also a class of information, at this point the subject can focus on alternatives. Having narrowed memory search to a class of information, this information can be used to eliminate alternatives that fall outside the class definition.

In this way, the subject has used information in his/her knowledge structure to simplify the task. For example, through the successful use of the stem as a cue for both context and class retrieval, the number of alternatives that receive consideration may possibly be reduced. The basis for the elimination of alternatives would be the observed incongruity between the memory structure defined in terms of context and class, and the alternatives contained in the item. A subject may stop at this point in processing and select an alternative. In this case, the subject would go to the next item.

The subject may persevere, however, and engage in one more level of processing. Having narrowed the search to a class within a context, a specific item or instance from within a class may be retrieved and serve as the basis for a match between a specific

memory representation and remaining alternatives. However, a person need not go through all of the stages in a serial manner. There are instances where it must be assumed that a person could bypass the class search and go directly from context to a specific memory representation. This model would suggest that the high level of performance typically associated with M-C performance is not due to the simplicity of the processing involved. Rather, the high level of performance may be due to the abundance of retrieval cues and their use in selecting an alternative.

While the level of performance in M-C testing is typically higher than for retention measures such as free recall, performance is not perfect. In these cases where performance is not perfect, informative feedback can serve two functions. In the case of a correct answer, feedback serves to confirm the correctness of the response. In the case of an error, feedback would provide information which could be used to correct the error. In terms of the M-C model, an error would be the result of a knowledge structure deficit that pertained to either context, class, or specific representation. Consequently, informative feedback could be corrective at any point depending upon the nature of the feedback.

Informative Feedback

Although feedback has been demonstrated to facilitate learning, unless the material to be learned is very easy, performance following feedback is not perfect. This is particularly true in the case of the type of learning here under consideration, productive learning.

It is the opinion of the present author that a consideration of errors made following feedback would provide useful information concerning the role of informative feedback in productive learning. For example, when number of correct responses is the dependent variable under consideration, little information concerning cognitive processing variables can be obtained because there is more than one way to get a correct answer with a M-C format. While there are problems in determining the processing involved in answering correctly, an error analysis would permit the determination of cognitive processes in responding incorrectly. It is assumed that a more adequate understanding of M-C performance can be obtained through the analysis of total behavior defined in terms of both correct and incorrect responding. While the analysis of correct responses have been used to better understand the effects of such task variables as length of retention interval

and length of feedback interval on M-C performance, attention is turning toward a consideration of errors as well. Specifically, in terms of M-C performance, a consideration of perseverative errors (Kulhavy & Anderson, 1972; Kulhavy, Yekovich & Dyer, 1976; Suber & Anderson, 1975) and different errors have been made as they relate to performance following feedback (Phye, Gugliemella & Sola, 1976).

However, prior to an analysis of error type, a consideration of the role of feedback from an information processing perspective is necessary. It is important at the outset to understand that here the assumption is made that a feedback procedure is esentially an additional study trial. As such, one need not postulate processing that is different from processing on other learning trials. Inasmuch as the standard feedback paradigm is a pretest - feedback - posttest design, one has the minimal basis for the measurement of change (i.e. two observations per subject). In essence, feedback provides the opportunity for a subject to confirm a correct response and/or change an incorrect response. The changing of an incorrect response is an instance of adjustment of existing knowledge structure or in the Piagetian sense,

"accommodation" has occurred. Accommodation used in the Piagetian sense refers to the modification of schema to match reality. Reality in this case being defined as experimenter defined correct responses. What is being considered with the proposed error analysis are instances where a subject failed to engage in accommodation when the basis for accommodation was provided through feedback.

Error Analysis:

The following is a logical analysis of the types of errors that occur on a M-C test following informative feedback. Logic suggests the identification of three types of errors that can be made on a M-C test following informative feedback about initial performance. The first type of error is perseverative in nature and will be referred to as a same error. In this case, an incorrect response made on the initial test was made again on the second test even though the subject was informed during feedback as to the correct answer. In this situation, the initial error perseverates. More specifically, not only was the same item missed on both occasions, but the same incorrect alternative was selected. The second type of error is a different error. In this case, an item is again missed on both occasions, but this

error is not perseverative in nature. For example, while the same item is missed on both occasions, different incorrect alternatives are selected on each occasion. Speculatively, it appears that the subject has obtained information during feedback to the effect that the original response was wrong but insufficient information to identify the correct alternative. This would be an instance of a form of knowledge that Ann L. Brown terms "knowing about knowing" (Brown, 1975, pp. 105). The third type of error is called a new error. In this case, an item which is answered correctly on the initial test is missed on the posttest following informative feedback. Here performance appears to be the result of a lucky correct guess on the initial test, the ignoring of feedback, then the commission of an error on retest. What may be happening here is the failure of a subject to process informative feedback because, "I got it right, therefore I must know the answer". It is suggested that these three types of error in combination with correct response performance must be considered in order to account for information processing in multiple-choice test performance. In contrast to previous studies

investigating errors in multiple-choice tests (Kulhavy & Anderson, 1972; Kulhavy, Yekovich & Dyer, 1976; Phye, Gugliemella & Sola, 1976), this error analysis accounts for all instances of incorrect responding.

As is the standard practice, the types of errors made would be recorded for each subject and the sum of each type would be expressed as a proportion of total errors. While the proportions would vary across subjects, in all cases where errors are made, the proportions would sum to 1.00 for each subject. Since error data are expressed as proportions, arcsin transformations should be performed on the raw data prior to data analysis.

The Role of Error Analysis in Informative Feedback:

The role of error analysis in informative feedback can also be considered from an information processing framework. For instance, feedback in the form of the correct answer is used to correct prior errors. Hopefully, the subject encodes feedback so that on the posttest the aforementioned M-C processing is fruitful. However, errors at posttest indicate difficulties with the encoding of feedback. The types of errors that are committed following feedback indicate that different types of processing may also be considered when analyzing errors.

When new errors are made, it appears that subjects don't encode feedback. Apparently, they assume that correct performance on the pretest demonstrated knowledge, when, in fact, the right response was the result of a guess. As a check on the assumption that the new error was the result of an initial guess followed by the ignoring of feedback, the proportion of new errors made on an immediate retention test following immediate feedback was computed by Phye & Gugliemella. With three alternatives per item, random selection which would indicate no knowledge of the right answer either initially at pretest or following feedback at posttest would be .33. The mean nontransformed proportion for new errors was .333. While this is not unequivocal evidence of random responding, it is certainly within expectations for a test with three alternatives.

In the case of different errors, what could be determining processing would be information concerning the inappropriateness of the response on pretest but insufficient information concerning the correct response. On the pretest the incorrect response could be the result of a guess as was the case with the new errors. In one instance (new error), the guess resulted in a right response and in

the other (different error), a wrong response. The information received at feedback concerning the status (i.e., right or wrong) of a response made on the pretest would influence the processing of feedback. At feedback when the initial response was wrong and the accommodation process was initiated but incomplete, a different error is observed on the posttest. It has been suggested that at posttest the learner who makes a different error has information available in memory storage to the effect that the response on the pretest was wrong. This information was obtained at feedback. Unfortunately, information as to the right response is not available in memory storage. With the different and new errors just considered, the breakdown in the accommodation process may be comparable to what Mayer (1975) called "condition two factors" related to the processing of meaningful information.

The perseverative error (same) appears to be a problem related to a deeper level of processing. Here, feedback may be attended to and received. The problem appears to lie with an inability to use feedback in order to restructure existing knowledge structure (accommodation). This inability to use feedback for accommodation as a result of a perseverative error may be related

to either the low meaningfulness of feedback or individual differences of a cognitive or personality nature. In the case of low meaningfulness of feedback, one would be considering an instructional or task variable. For example, if feedback was of a meaningless nature such that it would not serve as a retrieval cue for either context or a class of information within a specified context, the learner would not be able to relate or incorporate the informative feedback into existing knowledge structure. Individual differences in cognitive or personality characteristics must also be considered. For example, a source of perseveration which would yield a same error could be cognitive rigidity or inflexibility. In this case, information at feedback would be appropriate and incorporable in terms of a compatability between feedback and existing knowledge (meaningful) but the subject does not use the feedback to correct an error. Here, the lack of accommodation is due to a processing breakdown on the part of the organism. Personality factors that might contribute to a breakdown in processing would be factors such as test anxiety and overconfidence in initial response.

Individual Differences in Feedback Utilization:

Individual differences in organismic variables such as cognitive rigidity or inflexibility, background of knowledge, and stage of learning must also be considered as potential influencers of the commission of processing errors. The impetus for the inclusion of the individual differences parameter in a consideration of cognitive functioning comes from several sources with the efforts of Earl Hunt and colleagues probably being the most widely known (Hunt, Frost & Lunneborg, 1973).

While a few studies have considered cognitive and personality variables and their influence on the effects of feedback (Hansen, 1974) most attention has been focused upon the influence of task variables on the effects of feedback. A recent exception is the work of Kulhavy, Yekovich & Dyer (1976). When subjects worked through a 30-frame program and rated their confidence in their initial response prior to receiving feedback, regardless of correctness, high confidence responses followed by feedback were remembered significantly better on posttest. Currently, we are seeing increased attention being directed toward learner characteristics such as learner expectations (Kulhavy, Yekovich & Dyer, 1976) as well as other types of individual differences.

Theoretical and Methodological Application

The following study is an attempt to apply some of the aforementioned methodological and theoretical considerations in order to better understand the role of informative feedback in a classroom setting. It must be emphasized that this study was exploratory in nature. This study was not designed to be the definitive study that would challenge the proposed model of multiple-choice performance or the error analysis. As previously mentioned, initial steps at validation have been undertaken in the laboratory under simulated classroom conditions where greater freedom in the manipulation of independent variables is possible. These initial efforts (Phye, Gugliemella & Sola, 1976: Phye & Gugliemella, 1977) have been directed primarily toward the validation of the error model across different types of feedback conditions, feedback delay intervals, and types of retention tests.

As would follow from a consideration of complex learning tasks, interactions could take the form of an interaction between two task variables such as type of feedback and type of retention test or the interaction of feedback interval and retention interval.

Additionally, the inclusion of an individual differences parameter would permit the possibility of an interaction between subject variables and task variables. Of interest in the present study was the possibility of an interaction between individual differences on classroom performance in an undergraduate psychology course and the ability to use feedback to improve test performance on a comprehensive final examination.

Method

Subjects The original data pool consisted of 288 regularly enrolled in an undergraduate developmental psychology course at Iowa State University. In order to determine the effect of academic ability on the commission of different types of errors, data were analyzed for only 75 subjects. Subjects included in the study were approximately the top 10% (n=25), the middle 10% (n=25), and bottom 10% (n=25) of the class as determined by performance on three hourly exams given prior to the final comprehensive exam.

Procedure Each of the three hourly exams consisted of 50 multiple-choice items with four alternatives. The tests covered assigned

course materials and were not comprehensive in nature. The final was comprehensive in nature in that it covered material since the third exam plus material from the previous exams. Specifically, the final consisted of 60 multiple-choice items. Fifteen items were taken from each of the hourly exams plus 15 items over the new material covered since the third exam. All items taken from old exams had difficulty indexes ranging from .40 - .60. Following the selection of items for the final exam, the previous hourly exams were rescored following the elimination of items to be used on the final. After the rescored exams had been summed across the three hourly exams, the top, middle, and bottom 10% were determined for inclusion in the study. Procedure was undertaken in order to eliminate the potential confounding of classifying subjects on the basis of performance on the dependent variable (i.e. correct responses). While subjects knew that ¼ of the items on the final would come from material covered in each quarter of the course, they were not told that the items would come from hourly exams.

Feedback Informative feedback was provided on the second day following the administration of each hourly exam. This was the

first regularly scheduled class period following an exam. Each student in class was given a test booklet and their answer sheet that had been machine scored. Also, correct answers to all items were provided by means of a screen and overhead projector. All students were encouraged to study their performance and ask any questions they had pertaining to the exam. At the end of the feedback session, both exam booklets and answer sheets were collected.

Results

In keeping with earlier suggestions, both an analysis of correct responses and an error analysis were performed on the data.

Correct Response Data:

A 3(ability) x 3(hrly. test) x 2(repeated measures) analysis of variance having one between and two within subject factors was used to analyze the correct response data. The repeated measures in this case being scores on an hourly exam and the final. The analysis revealed a significant main effect for ability. $F(2,72) = 395.45$, $p < .0001$. This main effect was contained within two significant higher order interactions and will be further considered within the context of the higher order interactions. The two way interaction of ability and hourly test was also significant $F(4,144 =$

3.66, $p < .007$. The significant three way interaction contained the previous significant effects. The ability by hourly test by repeated measures interaction was also highly significant $F(4,144)=5.95$, $p < .0004$. Means were tested using the Tukey Honestly Significant Differences (HSD) test. As shown in table 1, the only group to demonstrate a significant change in performance following feedback was the top ability groups' improvement on items from the first test. While other groups exhibited increases in performance, no other differences between repeated measures

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were significant. As can be ascertained from table 1, ability groups differed significantly ($p < .05$) not only on each of the hourly tests but on the final exam as well.

Error Analysis:

The types of errors made were recorded for each subject and the sum of each was expressed as a proportion of total errors. While the proportions would vary across subjects, in all cases where errors were made, they would sum to 1.00 for any subject. Since error data were expressed as proportions, arcsin transformations were performed on the raw data prior to data analysis.

Separate one-way MANOVAs were also used to analyze error performance from each of the three hourly exams. On items from the first exam, a significant effect was found for ability in the commission of different errors $F(2,72)=3.77$ $p<.03$. The Tukey HSD test indicated that both the top and middle ability groups committed proportionally fewer ($p<.05$) different errors than the low ability group. On items from the second exam, there were no significant proportional differences among the ability groups in the commission of errors. However, on items from the third exam a significant effect was again found for ability in the commission of different errors $F(2,72)=3.64$ $p<.03$. As on test one, top and middle ability groups committed proportionally fewer ($p<.05$) different errors than the low ability group.

Discussion

In that this study was carried out in a naturalistic setting (i.e. classroom) there are shortcomings that should be considered. If one chooses to ignore a large body of literature (e.g. Sassenrath & Garverick, 1965) attesting to the fact that informative feedback has a facilitative effect in classroom learning (not only in terms of improvement of performance but resistance to forgetting), the lack of a control group in the present study that received no

feedback would be a matter of concern. However, since a subject's course grade was in part determined by performance on the final exam, ethical considerations prevented the inclusion of a "no feedback" control group.

The general impression to be obtained from a consideration of the correct response data is that there was not a widespread facilitative effect of informative feedback on long term retention defined in terms of a 3, 6, or 9 week interval. In fact, only the top ability group was able to use informative feedback to improve performance on the final and this was true only for items from the first exam. This last statement must be qualified since a review of table 1 indicates the possibility of a ceiling effect for high ability subjects on exams 1 and 2. Without the "no feedback" control group, it is impossible to say whether or not the fact that there were no significant decreases in performance was due to chance, extraneous variables, or the presence of feedback.

The error analysis does provide insight for a better understanding of the differences in cognitive processing involved in the inability to use informative feedback to promote long term learning. In other words, when asking the question "why wasn't

feedback used more extensively to correct misinformation?", some of the instances of inappropriate cognitive processing can be accounted for by differences in academic ability. On items from the first and third exams, the bottom ability group made proportionately more different errors than either the top or middle ability groups. According to the proposed feedback model, these results would indicate that relatively speaking, low ability subjects were more frequently in the position of knowing that their initial response was wrong but not being able to remember what was the correct answer that was provided during feedback. The feedback model suggests that a different error is the result of an unlucky guess (i.e. wrong response) on the pretest (hourly exam) followed by an inability to retrieve the correct response (feedback) from memory store at posttest (final exam). This would suggest that students of lower academic ability are more likely to have difficulty with the accommodation process as a result of what Mayer has called condition two factors related to the processing of meaningful information (Mayer, 1975). Condition two factors relate to how much prerequisite knowledge the learner has. In the present study, the basis for ability grouping certainly reflects

differences in prerequisite knowledge. Mayer has indicated that a two stage model of internal processing would predict that differences in prerequisite knowledge would be reflected in differences in amount learned. The two stage model would predict more learning and better posttest performance for subjects with appropriate prerequisite knowledge. While present correct response data would confirm this prediction in terms of amount learned, the error data also speaks to differences in the processing of feedback as a result of differences in prerequisite knowledge.

In response to the question "why wasn't feedback used more extensively to correct misinformation?", consideration must be given to differences in academic ability that reflects prerequisite knowledge that would influence the amount learned and posttest performance. Also, differences in prerequisite knowledge influences the types of cognitive processing engaged in as witnessed by the greater proportion of different errors committed by low ability subjects.

The study presented above was included not because of its significant contribution to the research literature, but as an example of the heuristic potential that a cognitive perspective has for the consideration of the role of informative feedback in productive learning.

Summary

Within the context of M-C processing, it is suggested that a consideration of informative feedback from a cognitive perspective that emphasizes an information processing approach has much to offer future research. While the use of correct responses as the dependent variable of concern in studies of feedback has been and will continue to be extensively used, a more complete understanding of the processing involved in using feedback requires the analysis of both correct responses and errors. A consideration of both correct responses and errors from an individual differences viewpoint is possible and in many instances should provide a better understanding of individual differences in accommodation of schema (the use of feedback to correct an error) and failures to accommodate (errors following feedback).

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Table 1

Ability Group Performance on Items From Hourly Exams and Following Feedback, the Final Exam

Ability	Correct Response Performance					
	Exam 1	Final	Exam 2	Final	Exam 3	Final
High Ability	10.92	13.10	12.50	12.30	12.52	11.92
Middle Ability	9.40	8.68	8.92	8.88	8.68	9.08
Low Ability	6.68	6.20	5.16	5.64	7.20	7.40

Figure Caption

Figure 1 Processing Model of Multiple-Choice Test Performance

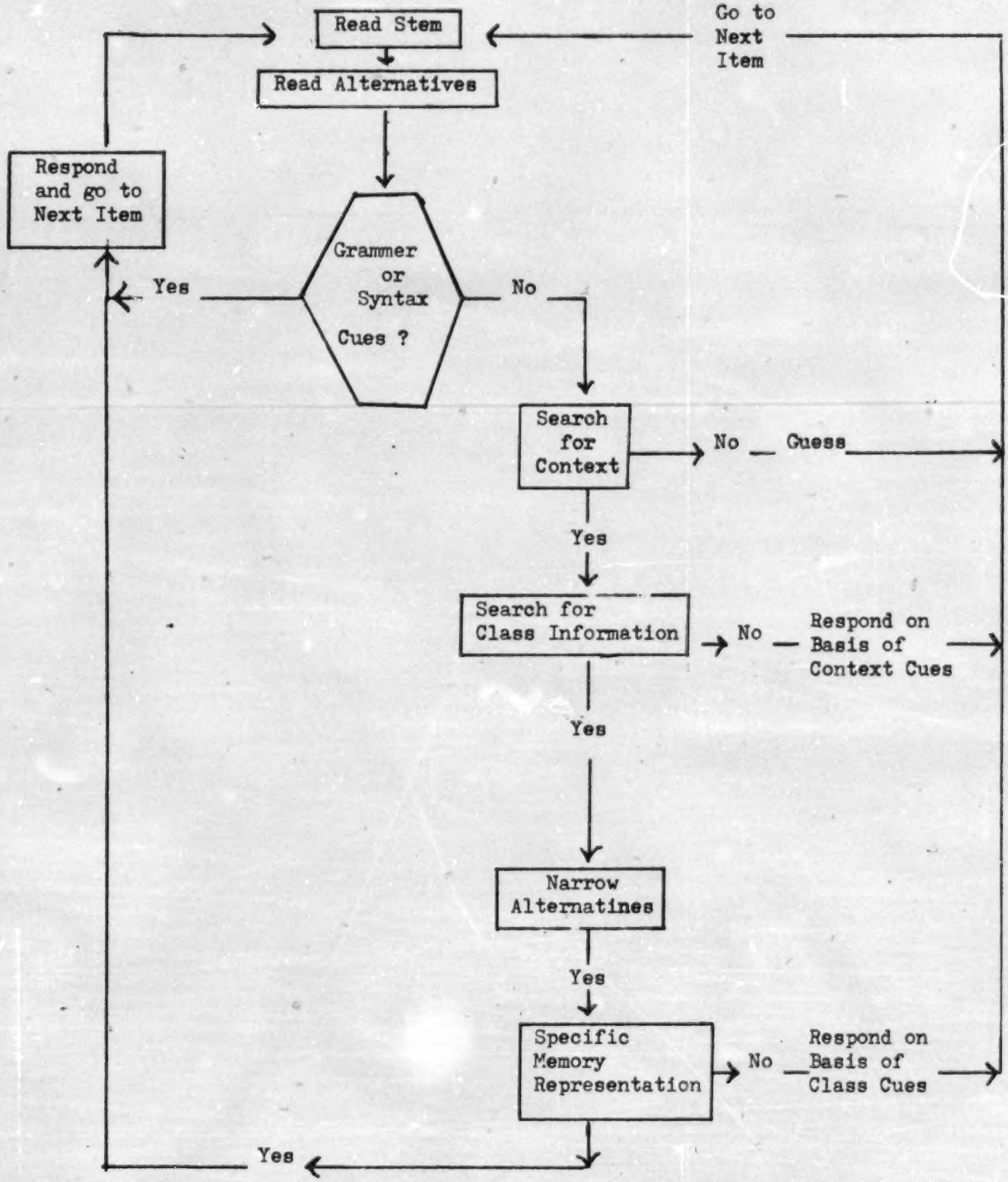
Read Stem
Read Alternatives
Go to Next Item
Respond and go to Next Item
Grammer or Syntax Cues ?
Yes
No
Search for Context
No
Guess
Yes
Search for Class Information
No
Respond on Basis of Context Cues
Yes
Narrow Alternatines
Yes
Specific Memory Representation
No
Respond on Basis of Class Cues
Yes

Figure 1